Creating a Smart Room using an IoT approach

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Problem Definition

- Create a smart meeting room using energy efficient and effective services that minimize:
  - environmental impact
  - monetary costs
  - user discomfort
  - delays/utilization of resources
- In other words:
  - minimizing unnecessary heating and, cooling and light usage
  - comply with international policies (i.e., health and safety standards)
  - have service available on demand
  - avoid needless usage of resources
- Within the room there is the need to
  - interconnect several heterogeneous devices
  - apply/develop processing algorithms in several computer languages/APIs
 - use cheap consumer devices

Environment to solve this problem

- Devices and algorithms may be interconnected using an IoT platform
  - sensing and actuating devices may be enhanced with network capabilities
  - processing algorithms may run within a cloud infrastructure
  - devices/algorithms may be exposed as services
- A rule-based Decision Making module is used to handle all relative tasks
  - receives input from all sensors and processing units
  - triggers actuations based on current needs
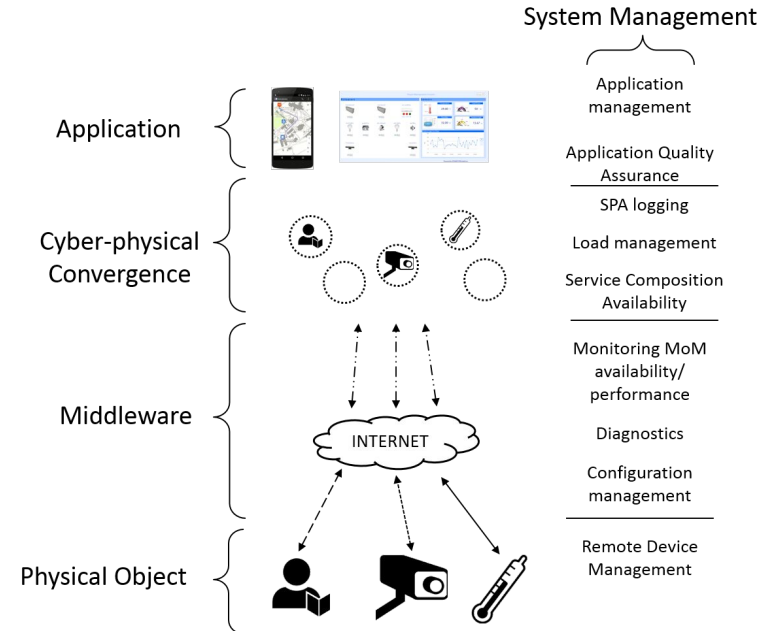- We have implemented all the aforementioned on top of the SYNAISTHISI platform
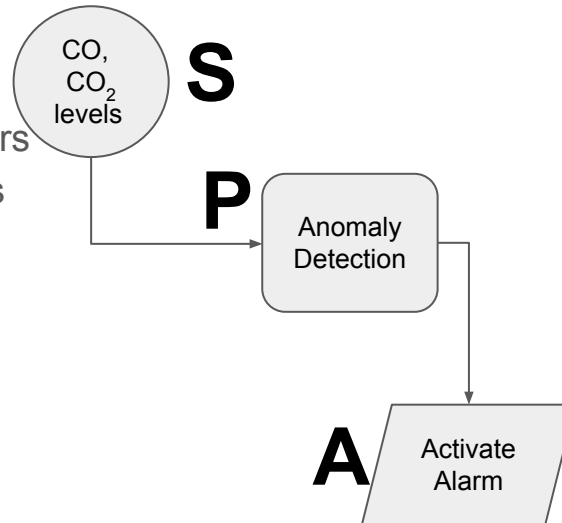
The SYNAISTHISI platform

- SYNAISTHISI is an integrated platform that allows humans, systems, machines and devices for the creation and management of services
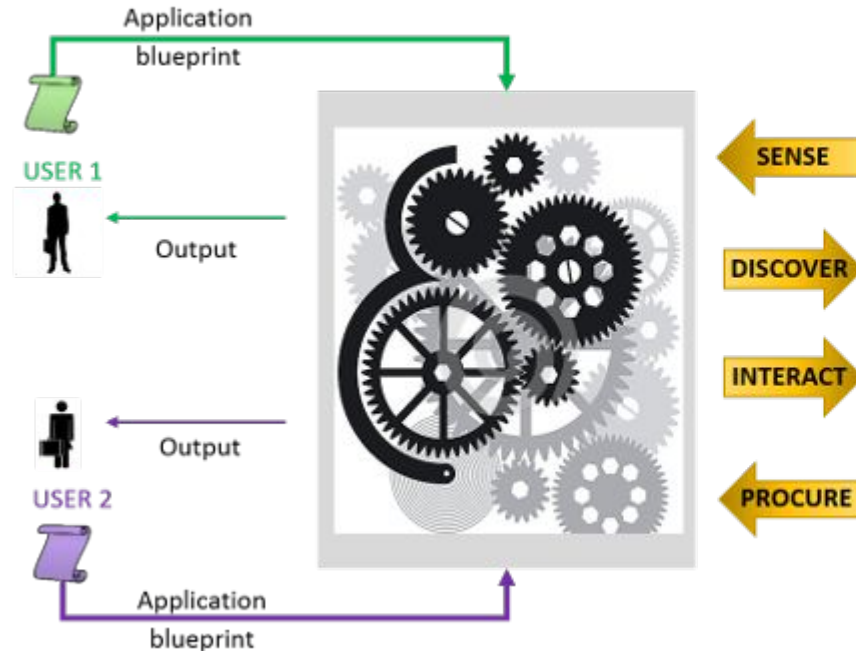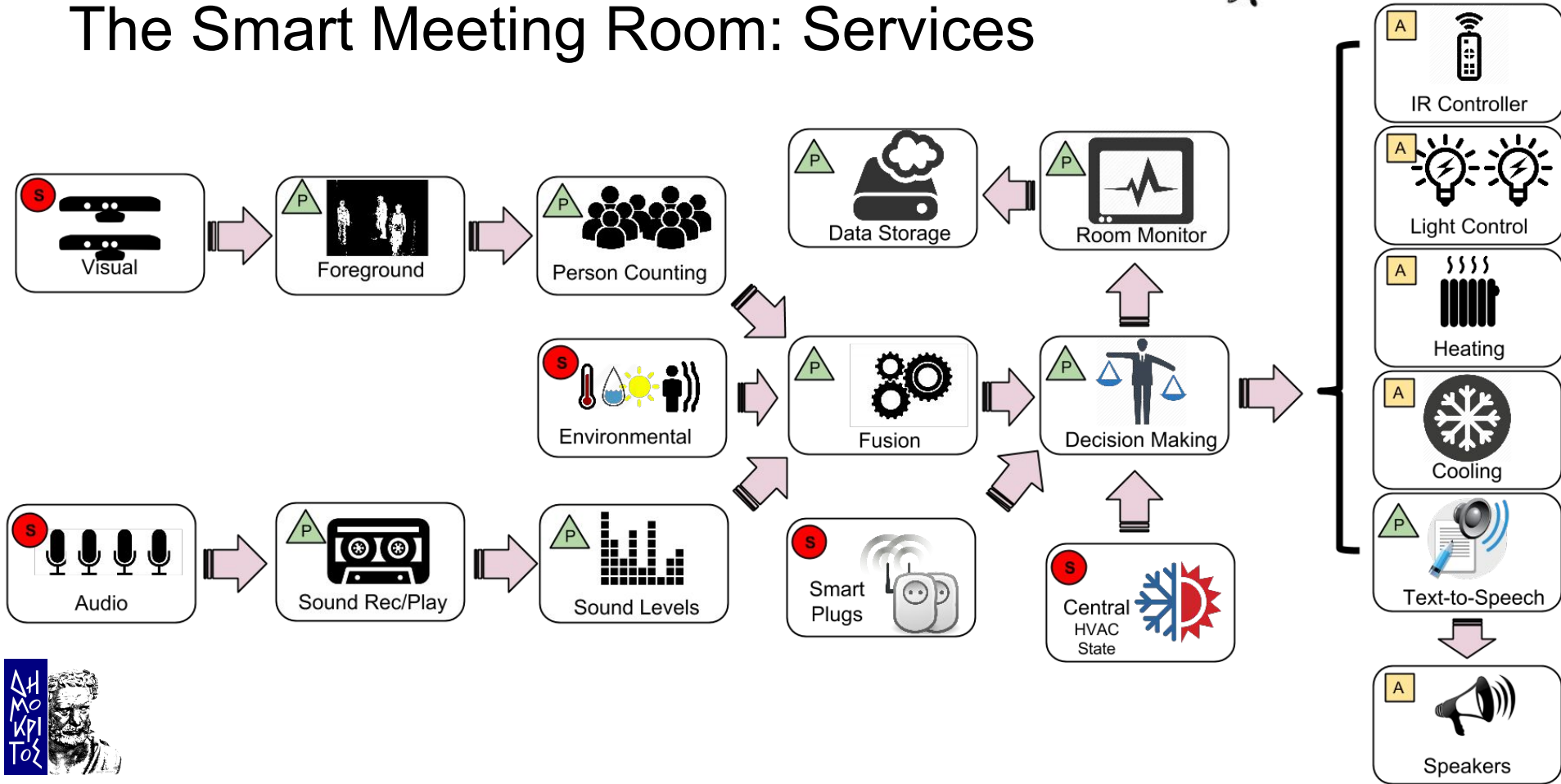
The SYNAISTHISI platform (cont'd)

- Everything is a Service:
  - (**S**)ensing Services
    - Temperature sensors
    - Cameras
    - Consumption meters
    - …
  - (**P**)rocessing Services
    - Audio Analyzers
    - Image Processors
    - Decision Makers
    - …
  - (**A**)ctuating Services
    - Speakers
    - Plug Switches
    - Motors
    - …

- Layered Architecture
- Bidirectional communication among layers
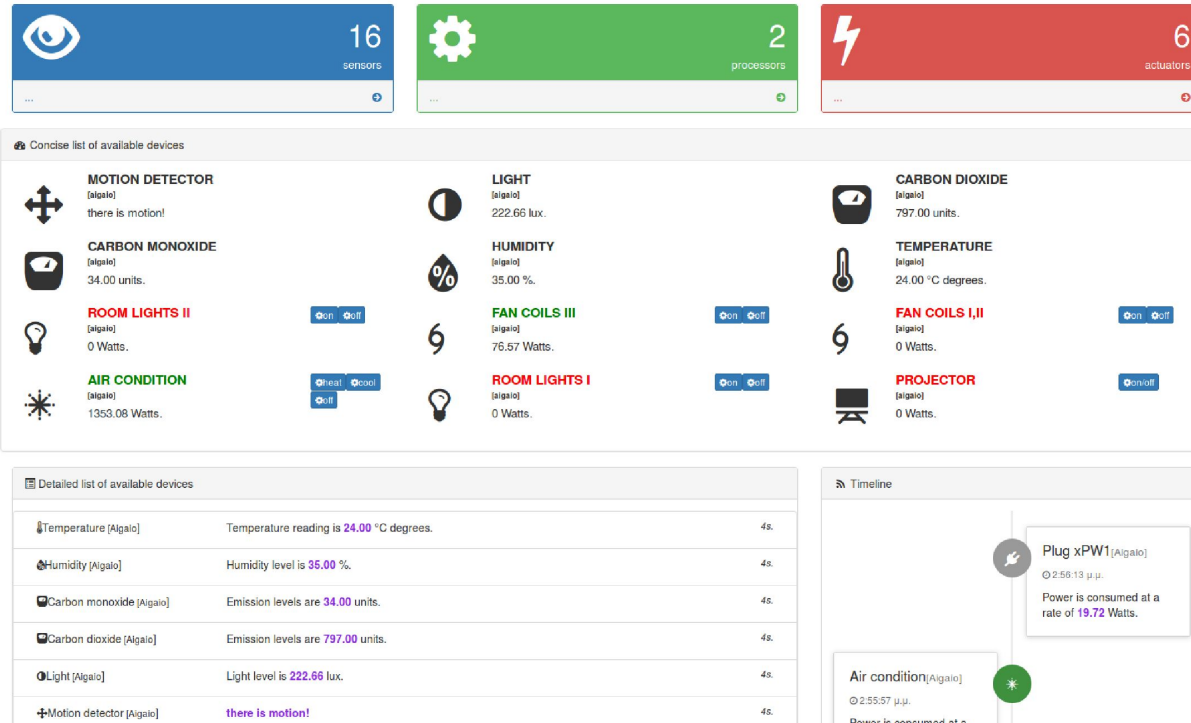- Seamless interconnection of heterogeneous modules

CO, CO_2 levels

S

P — Anomaly Detection

A — Activate Alarm

Application

Cyber-physical Convergence

Middleware

INTERNET

Physical Object

System Management
- Application management
- Application Quality Assurance
- SPA logging
- Load management
- Service Composition Availability
- Monitoring MoM availability/ performance
- Diagnostics
- Configuration management
- Remote Device Management

The Smart Meeting Room: Services
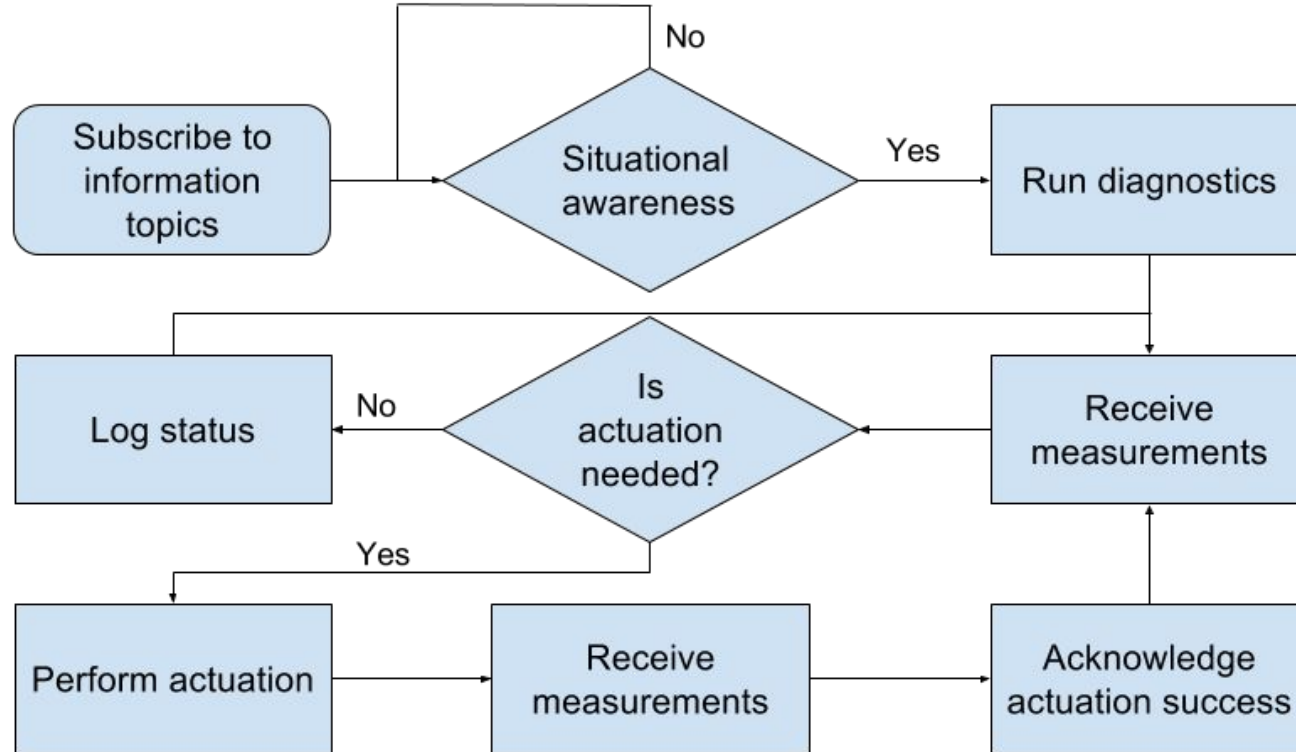
The Smart Meeting Room: Dashboard

Decision Maker Functionality

Decision Maker Functionality

- DM inputs

Context	Details
Event Processing	Fire detection
	People's presence in the room
Sensor Readings	Indoors temperature
	Outdoors temperature
	Indoors humidity
	Outdoors humidity
	Indoors luminosity
	Outdoors luminosity
	Number of people in the room
	Dangerous gas levels
	Audio levels
	Motion detector
	Power plug measurements (A/C, Central HVAC system's motors, Projector, Lights (front, rear), General use plugs)
Heating Optimizer Module	Optimized target temperature for room interior
Meeting Schedule Module	List of daily meetings reserved for the room
HVAC Module	Operation status of central HVAC system
Human Input	Preferred temperature, Manual on/off commands, etc.

Decision Maker Functionality

- Services the DM may actuate

Description
Light switches
Mains switches
IR actuators
Text-to-speech synthesizers
Notification publishers

Decision Maker Functionality

Condition	Actions
Fire alarm	
Temperature is high and emission levels are high	Repeated announcement «Fire alert is activated», Actuate Alert notification
Occupancy-dependent decisions	
Given that the room is empty	Turn all appliances off
People's entrance	Lights on, Announcement «Welcome, people»
Start of the meeting	Front lights off, Projector on, Announcement «The meeting is about to start»
End of the meeting	Turn all appliances off
Given that the room is occupied and current time is 00h00-06h00	Actuate alert notification

Condition	Actions
Temperature optimization	
Temperature is higher than the target, outdoors temperature is higher than indoors	Turn A/C in cooling mode, or fan coils on
Temperature is lower than the target, outdoors temperature is lower than indoors	Turn A/C in heating mode, or fan coils on
Temperature is lower than the target, outdoors temperature is higher than indoors	Turn all off, announce "Please, open the windows for air refreshment"
Temperature is higher than the target, outdoors temperature is lower than indoors	Turn all off, announce "Please, open the windows for air refreshment"
Temperature is equal to target	Turn heating/cooling appliances off
Given that the room is empty	Turn heating/cooling appliances off

Evaluation

Smart Meeting Room Evaluation
Visitor Questionnaire

Please answer the following questions, after the end of the meeting, based on your experience during your stay in the smart meeting room:

1. Were you satisfied with the room temperature? (1: Very dissatisfied - 5: Very satisfied)
   1☐ 2☐ 3☐ 4☐ 5☐

2. Were you satisfied with the room lighting? (1: Very dissatisfied - 5: Very satisfied)
   1☐ 2☐ 3☐ 4☐ 5☐

3. Did you feel your privacy being violated during your stay at the room (e.g. due to cameras and microphones present?) (1: Not at all - 5: Extremely)   1☐ 2☐ 3☐ 4☐ 5☐

4. Were you satisfied with the automations of the room? (1: Very dissatisfied - 5: Very satisfied)   1☐ 2☐ 3☐ 4☐ 5☐

5. If you experienced important issues with the room, please report them. (Free Text)

6. If you have any suggestions, please share them with us. (Free Text)

7. What is your gender?   Male ☐ Female ☐

8. Please, specify your age.   <18☐ 18-25 ☐ 25-30 ☐ 30-40 ☐ >40 ☐

9. What is your educational level?
   High School graduate☐ Bachelor's degree ☐ Master's degree ☐ PhD degree ☐ Other ☐

Thank You!

Smart Meeting Room Evaluation
Coordinator Questionnaire

Please answer the following questions, after the end of the meeting, based on your experience upon interacting with the dashboard:

1. Does each icon successfully actuate its associated device? Yes ☐ No ☐

2. Please, report any problems related with the actuation of the devices. (Free Text)

3. Are you satisfied with the responsiveness of the interface to real world events? (1: Very dissatisfied - 5: Very satisfied)   1☐ 2☐ 3☐ 4☐ 5☐

4. Did you experience any delay between the manual triggering of a device and the status update on the dashboard? no delay ☐ short delay ☐ long delay ☐

5. Do you think the Dashboard controls are intuitive for a first-time user? (1: Not intuitive - 5: Very intuitive)   1☐ 2☐ 3☐ 4☐ 5☐

6. Are you satisfied with the colors (scheme/sizes)? (1: Very dissatisfied - 5: Very satisfied)
   1☐ 2☐ 3☐ 4☐ 5☐

7. If you experienced important issues with the layout, please report them. (Free Text)

8. What kind of device did you test the dashboard on? Laptop ☐ Tablet ☐ Smartphone ☐
   Please provide the exact model (free text):

9. What is your gender?   Male ☐ Female ☐

10. Please, specify your age.   <18☐ 18-25 ☐ 25-30 ☐ 30-40 ☐ >40 ☐

11. What is your educational level?
    High School graduate ☐ Bachelor's degree ☐ Master's degree ☐ PhD degree ☐ Other ☐

Thank You!

Evaluation

- Users of various ages and education levels used the smart meeting room
- Results show that users have been in general quite satisfied both with the dashboard and the smart room automations
- Feedback helped further improve the deployed services and the dashboard; a number of proposals have already been integrated

Conclusions & Perspective

- We have presented an IoT-ready smart room equipped with numerous sensors, processors and actuators
- All connected devices can be controlled manually or automatically with the proposed Decision maker service
- We asked users to evaluate the smart room; user proposals & comments taken into account
- The IoT architecture facilitates the addition of services

Perspective

- Add more sensors and more elaborate processing units
- Use a learning-based (complex) event recognizer
- Adopt a learning decision making approach
- Use AI-based computer vision approaches to measure user comfort
- Integrate a set of smart agents for temperature optimization, i.e., take into account renewable consumption levels, current electricity prices, and user preferences regarding the room temperature, and control the HVAC equipment accordingly

Any questions?